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FABRICATION OF GLASS GAS CELLS FOR THE HALOE AND MAPS SATELLITE EXPERIMENTS

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1. Introduction

1.1 HALOE and MAPS Experiments

The Halogen Occultation Experiment (HALOE) and Measurement of Air Pollution from Satellites (MAPS) are satellite experiments to measure, on a global basis, the concentration of trace gases in the Earth's atmosphere. These experiments are part of NASA's ongoing program of research, technology development, and atmospheric monitoring.

HALOE (ref. 1) measures the concentration profiles of O_3, HCl, HF, NO, CH_4, H_2O, and NO_2. (In order to correlate the data as a function of atmospheric pressure, the CO_2 transmittance profile is also measured.) These species will permit the scientific community to study stratospheric ozone depletion resulting from chlorine in the stratosphere and to determine the relative amounts of chlorine from natural and man-made sources. Stratospheric ozone is vital to terrestrial life because it filters out the life-threatening solar ultraviolet radiation. Thus, the possibility of ozone depletion resulting from man-made chemical compounds entering the atmosphere has been a major concern for the past 2 decades (e.g. refs. 2 to 5). The concern over the particular effects of chlorine released from man-made chemical compounds (especially the fluorocarbons $CFCl_3$ and CF_2Cl_2) used as refrigerants, cleaning compounds, and foaming agents has surfaced more recently (refs. 6 and 7). HALOE will address this latter concern directly, but will also provide data for extensive studies of stratospheric chemistry as a whole.

The MAPS experiment flew on the second flight of the Space Shuttle during November 1981 and is scheduled for reflight during October 1984. The experiment measured the mixing ratio of carbon monoxide (CO) in the middle and upper troposphere. Carbon monoxide is produced, at least in part, by the incomplete combustion of fossil fuels (ref. 8), and since man's activities

involve substantial burning of these fuels, it is believed that man's activities are responsible for from 25 to 50 percent of the total atmospheric CO on a global basis (ref. 9). This is further borne out by the fact that the available data show Northern Hemisphere CO concentrations which are at least twice as large as those in the less densly populated Southern Hemisphere. MAPS will provide the data needed to validate the theories and mathematical models required to fully understand the relevant atmospheric physics and the effects which result from man's injection of CO into the atmosphere.

1.2 Gas Filter Technique

Both MAPS and HALOE use the Gas Filter Correlation Radiometer (GFCR) technique. In this technique, source radiation from the Earth (MAPS) or the Sun (HALOE) is directed into the instrument. Inside the instrument the radiation traverses two parallel paths: One path is directed through gas cells which contain the gases of interest, the other path is evacuated. At the end of each path the radiation is collected by detectors which convert the radiative energy into electrical energy. Since the gases in the cells act as highly selective filters, there is a difference between the electrical output from the detector at the end of the gas cell path and the detector at the end of the vacuum path. This difference is related to the amount of gas in the atmosphere which has absorption features which correlate with those of the gases in the cells. Knowledge of the source brightness temperature, the gas concentrations in the cells, detector efficiency, and atmospheric parameters such as temperature and pressure can be used in conjunction with the output signal to determine the target gas concentration in the atmosphere.

The key to success of the GFCR technique is the ability to contain specific quantities of the gases of interest at known pressure and temperature for extended periods of time, i.e. several years. In both MAPS and HALOE this is accomplished by containing the gases in sealed cylinders called gas cells.

2.0 Pre-Assembly Preparations

The HALOE gas cells for CH_4 and NO (figure 1) and the MAPS gas cells (fig. 2) were fabricated by using the procedures to be described in this report. (The HALOE gas cells for HF and HCl were fabricated under contract to NASA and will not be discussed.) The quality of the completed cells was directly related to the amount of preparation expended in several areas: materials selection, window inspection, window pairing and aligning, cell body preparation, assembly fixture fabrication, and the development of cleaning procedures. Each of these will be discussed in some detail.

2.1 Materials Selection

An essential part of the cell fabrication process was the selection of materials to be used for the heating elements and assembly fixtures. These materials and their requirements were selected as the result of an experimental process.

The graphite heating elements used during the assembly procedures described in section 3.3 were machined from pressed graphite blocks with an apparent density of 1.8 g/cm^3. Experiments with heating elements machined from lower density material showed that they deteriorated very rapidly during the glass-to-sapphire fusion process. This caused uneven heating which resulted in non-uniform melting of the glass and voids at the glass-to-sapphire interface.

The heating element pedestal and the short cell assembly fixtures (section 3.3) were fabricated from natural stone magnesium silicate or steatite. This material was selected because it was easily machined and had a very low coefficient of thermal conductivity. Experience showed that this material tended to grow when first heated. Based on this the pedestal and fixtures were heat treated and then remachined as required to meet dimensional specifications. After heat treatment the material demonstrated good dimensional stability.

It will also be noted in the procedures that the glass and sapphire cleaning procedures specify the use of NOCHROMIX* solution. Other, comparable cleaning solutions may have been available but the authors did not find them within the time frame allowed for cell fabrication. This solution had several desired characteristics: Good cleaning capability, room temperature application, no residue on the parts cleaned.

2.2 Sapphire Window Inspection, Pairing, Aligning, and Marking

This section will detail the procedures for inspecting the HALOE cell windows. The measurement specifications are given in figures 3 and 4. All of the inspection equipment used except a 10X standard binocular microscope is shown in figure 5. All window handling was done with the aid of plastic forceps, and the inspector was required to wear clean nylon gloves.

2.2.1 Window Inspection Procedure

The inspection process began with an initial cleaning of the windows. (The cleaning procedures will be described in section 2.5.) The cleaned windows were first examined with the 10X microscope for scratches, cracks, chips, or other flaws which would have caused the rejection prior to further inspection. The second step was to place the window in the appropriate holder and examine it with the Polariscope shown in figure 5 to insure that it met the requirements (section 3.2) of having been properly cut from the original crystal. As a third step, the window was removed from the holder and inspected for flatness with the aid of the optical flat illuminated by the sodium vapor lamp with the frosted glass plate acting as a diffuser.

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*NOCHROMIX is a registered trademark of the Godax Laboratories, Inc., NY, NY

The window was then returned to the holder which was positioned on the anvil of the dial indicator shown. The 0.0001-inch resolution indicator pointer was positioned within 1/16-inch of the outer edge of the window. The window and holder were rotated on the anvil, and the readings of the dial indicator were used to determine the amount by which the windows deviated from constant thickness. Since the HALOE windows were known to be wedged, the dial indicator readings were used to locate the thinnest point on the window. This was marked with an indelible black marking pen. The window was removed from the holder and its thickness at the thick and thin spots measured with a micrometer. Finally, the outside diameter was measured with a vernier caliper. All data were recorded on an "Assembly History Record" sheet (Langley Form 155) and the window, wrapped in lens paper, placed in a plastic bag marked with the same number as the data sheet.

2.2.2 Single Window Refraction Angle Measurement

Since the HALOE windows were wedged it was necessary to pair and pre-mark them so that the finished cell would cause minimum refraction of the optical beam. This was accomplished using the equipment shown in figure 6.

The laser was used to project a spot of light on a target located approximately 10 m (30 feet) from the copper mandrel shown. Prior to making any measurements, the laser-mirror system was aligned such that the laser beam was centered in the bored hole which runs the full length of the copper mandrel. The ends of the mandrel had been machined to provide the minimum beam refraction for perfect windows.

As a first step, the refraction angle of each window was measured. Each window in turn was placed on the end of the mandrel closest to the laser, with the black mark (thin spot) approximately 90° from the top of the mandrel as indicated by the two small holes drilled normal to the axis of the mandrel.

Care was taken to insure that the marked window surface was placed away from the mandrel. The window was held in place with the Teflon end caps shown. The procedure for measuring the window refraction angle was as follows:

(1) Mark the target at the point where the undisturbed laser beam hits the target.

(2) With the window in place and the mandrel seated in the V-block, mark the point where the laser beam hits the target.

(3) Rotate the mandrel in the V-block approximately 60° and mark the target.

(4) Repeat step (3) several times until the mandrel has been rotated through 360°.

At this point the marks on the target formed a circular pattern around the center indicated by the undisturbed beam. The diameter of this pattern was used as a measure of the refraction angle.

2.2.3 Window Pairing and Aligning

Windows with a common refraction angle circle diameter, as described in section 2.2.2, were selected in pairs. To the greatest extent possible, the circle diameters were matched to within 3 mm.

Each pair of windows was placed on the copper mandrel (fig. 6) to insure that the combined refraction angle was as small as possible and within the 3 arc min specification (1 arc min desired) for optical alignment. The windows were located on the mandrel with the following restrictions: black marks away from the mandrel, black marks 90° from the top of the mandrel and 180° away from each other, windows held in place by the Teflon end caps. The undisturbed laser spot was marked on a clean target. The spot where the laser beam hit the target after passing through both windows was also marked. The windows on the mandrel were then slowly rotated relative to each other until the point

where the separation between the refracted and unrefracted beams was a minimum. At this time, both windows were marked with a red ink spot placed near the edge of the window and in line with the top of the mandrel.

2.2.4 Window Marking

The red spot indentified above was the alignment reference for final cell assembly. Since the ink spot would not withstand the cleaning process it was replaced with a glass decal applied near the edge of the window on the same radius, and on the same surface, as the red spot. Since glass decals require heating in an annealing oven, it was necessary to insure that the windows remained in pairs. This was accomplished by mounting the windows in foam quartz blocks (fig. 7) which were code marked to identify the appropriate "Assembly History Record" page number for each window. After this marking process, the windows were returned to their numbered plastic bags and placed in storage until needed for cell assembly.

2.3 Cell Body Preparation

All HALOE and MAPS 1-inch cell bodies were cut from Kimble* IN-3 glass which had been purchased already drawn to the proper diameter and wall thickness. For the MAPS 2-inch diameter cells, it was necessary to spin the glass tubing to the correct diameter. First the tubing was cut to a length approximately 0.03 inches longer than the desired finished length. The ends of the tubing were ground with a cylindrical grinder and fine diamond grinding wheel until the length was reduced to 0.005 inches longer than the desired finished length. The ends were lapped to remove tool marks starting with 1000 grit silicon carbide and finishing with 303 aluminum oxide to produce smooth,

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*Kimble Glass Division of Owens-Illinois

chip-free ends. The lapped ends were etched for 1-1/2 minutes in a 10-percent HF solution to remove any residual lapping compound or other contaminants. Finally the ends were lightly fire polished to flow in the lapped surface and remove all sharp edges. The tube was inspected for chips, cracks, and voids which might affect the seal, and then stored until needed.

The cell designs (figs. 8 and 9) show that fill tubes are required for the purpose of filling the cells with the specified gases. These fill tubes were designed with IN-3 glass at one end to mate directly with the cell body and Pyrex glass at the end where they are installed into the gas fill apparatus. Because IN-3 and Pyrex have significantly different coefficients of expansion, it was necessary to fabricate the fill tubes with graded seals as follows: 1/4-inch diameter Pyrex, 1-3/8 inches long; 6-mm diameter Corning No. 3320 (Uranium glass) 1/8-inch long; 6-mm diameter Corning No. 7052 glass, 1/8-inch long; and 5-mm diameter Kimble IN-3 glass, 1-1/4 inches long. The total fill tube length did not exceed 2-7/8 inches. (Note that for the long HALOE cells, only one of the fill tubes was used for cell fill operations. The second tube was simply a piece of IN-3 glass tubing which was used to facilitate the cell cleaning process.)

After a number of fill tubes were fabricated, they were assembled to the cell body with the aid of the fixture shown in figure 10. The cell body was clamped between the spring loaded end caps which also acted to form a glassblower's pressure seal. The centering bar was locked in position on the frame so that the centering bar was aligned with the desired location of a fill tube. The assembly was clamped into a glassblower's lathe and the fill tube mating area heated until an opening could be blown into the cell wall. At this time the prefabricated fill tube was mounted in the opposing lathe chuck and

the seal was made as shown in figure 11. When the cell body was completed it was annealed at 565°C for 15 minutes and allowed to slowly cool to room temperature.

2.4 Assembly Fixture Description

The assembly fixture (fig. 12) consisted of a 3-axis translation table fastened to a base plate. The base plate was made of 1-inch thick aluminum, 8 inches wide by 10 inches long with a 3/4-inch diameter steel rod placed near one end of the plate. This rod held an aluminum block with a hole through it to allow height adjustment. The aluminum block had a pivoting hinge plate attached to it to provide adjustment for the 0.004-inch wedge in the HALOE windows as well as the unwedged MAPS windows. The hinge plate had a vee block attached to it that pivoted at the bottom attachment and an arced slot to allow side adjustment which was controlled by opposing screws.

A 1.090-inch diameter by 4-inch long aluminum rod (fig. 13) was machined with square ends and placed in the vee block. An indicator with 0.0001-inch sensitivity was used to indicate the end of the aluminum rod to acquire a true end surface that was square with the base plate. The appropriate offset (0.004 inches for HALOE or 0.000 inches for MAPS) was then set with the controlling screws and all positions were locked. The 3-axis translation table was placed under the vee block with a steatite pedestal attached to the top of the table. A graphite block was machined to fit the top of the steatite and was locked in position with a graphite dowel pin. The top of the graphite block was counterbored to 0.015 inches deep by 1.125 inches in diameter to align the sapphire window. The steatite block had a hole drilled in the side with a hose nipple attached for the vacuum line (fig. 12). A hole drilled from the top of the steatite block intercepted the side hole to create a vacuum channel to the bottom of the graphite block. The graphite block was grooved and drilled to

allow for a vacuum passage to the underside of the sapphire window. This vacuum was very important since it helped maintain surface contact between the sapphire window and graphite block so as to give improved heat transfer from the heated graphite to the sapphire window. As noted in section 2.2.4, the only mark on the windows was the glass decal which designated the point on the window which was in line with the fill tubes. In order to insure correct alignment during assembly, it was necessary to etch a mark on the graphite block to which each window mark could be referenced and to insure that this mark was aligned with respect to the fill tubes when the cell body was clamped into the vee block. The vee block hinge adjustment required that the fill tubes be positioned 180° from the vertex of the V in the vee block. This line was projected onto the graphite block by means of an aluminum bar whose surfaces were machined to form a square. This bar, when clamped into the vee block, provided an edge which indicated where the line through the fill tubes would intersect the graphite block.

2.5 Cleaning Procedures

Cleanliness was a major concern during every step of the fabrication process. In order to achieve the optimum cleanliness within the available working constraints, the following rules were imposed: (1) The sapphire windows were always handled with clean tweezers or forceps, (2) white nylon gloves were always worn during the inspection and assembly processes, (3) cell bodies and windows were cleaned using the procedures given below prior to both the inspection and assembly processes, (4) fill tubes and sapphire windows were loosely capped during annealing operations, and (5) after final cleaning, the finished cells were kept under vacuum until delivered to the bonded stores area or the gas cell fill station.

2.5.1 Pre-Fabrication Cleaning

(1) A cleaning solution was made by dissolving two packages of NOCHROMIX™ in 5 pints (9 pounds) of concentrated (36 normal) sulfuric acid (H_2SO_4).

(2) The cell body and/or windows were soaked in this cleaning solution for 15 minutes or longer at room temperature. (Heating was found to be detrimental to the cleaning action.)

(3) All parts were rinsed in five changes of deionized water.

(4) All cell components were placed in a stainless steel pan and completely submerged in deionized water. The pan was covered to prevent airborne contaminants from reaching the water.

(5) The pan was heated to bring the water to a light boil before using parts in the fabrication process.

(6) All parts were blown dry with dry N_2 or other inert gas immediately after removal from the boiling water.

3.0 Cell Assembly

3.1 Cell Requirements

The HALOE and MAPS gas cells were designed to meet the harsh vibration, thermal, and vacuum environments associated with the launch and operation of satellite experiments. These cells were also designed as basic optical components so that stringent requirements were imposed on the alignment of the cell windows to the cell bodies. Furthermore, the physical characteristics of the cells were very different (figs. 8 and 9) so that each set of cells required special treatment during the assembly process. For example, the HALOE cells utilize wedged windows to minimize Fabry-Perot interference effects (e.g. ref 10) on the measured signal. These wedge angles, however, presented the potential for severe refraction effects, and thus it became necessary to

insure that the windows were mounted at the prescribed angles relative to the cell body axis. As another example, the MAPS cells were very short, and specialized jigs and holders were required to hold the cells during the assembly process.

3.2 Glass-to-Sapphire Seal Requirements

The techniques for fabrication of seals between sapphire and borosolicate glass have been documented (e.g. refs. 11 and 12). The basic requirements are that the glass have a coefficient of expansion close to that of sapphire, and that indirect heating be used to provide a controlled uniform temperature at the glass-to-sapphire interface. The heating technique selected for the HALOE and MAPS cell assembly process was that shown in references 11 and 12, i.e., heating a graphite block by induction from an RF coil. Several other considerations were noted during conversations with experts in the glassblowing field: The windows must have been made by cutting normal to the sapphire crystal growth axis; the window diameter should exceed the glass tube diameter by approximately the tube wall thickness; and at the time of sealing, the glass must be hot enough to wet the sapphire and form a meniscus. Each of these considerations was offered as a way of reducing or eliminating stresses in the finished seals. They were all followed in the development of the assembly techniques given below.

3.3 Assembly Procedures

The final assembly of each gas cell was performed according to the following detailed procedures and with the aid of the assembly fixture described in section 2.4.

3.3.1 Procedures for Assembling the Long HALOE Cells

(1) Position the fixture in front of the RF induction heater with the graphite heating element centered in the induction coil.

(2) Connect a vacuum pump to the vacuum fitting in the steatite pedestal.

(3) Place the shroud in position and connect the inert gas purge feed line to a supply of inert gas such as argon or nitrogen.

(4) Use a mild jet of inert gas to blow any loose dust from the surface of the graphite, and cover the graphite and shroud with a piece of clean, stiff, lint-free material to act as a dust cover.

(5) Clean one cell body and one matched pair of windows. Use procedures given in section 2.5.

(6) Remove one window from the boiling water with plastic tweezers. Use inert gas to blow dry the window. Inspect the window with the aid of a magnifying glass, and remove any foreign material (dust, etc.) with a clean cotton swab and inert gas.

(7) Remove the temporary dust cover and place the window on the clean graphite heating element. The window should be centered in the pocket machined into the graphite and installed with the window surface containing the alignment mark facing the graphite and pointing directly at the alignment mark on the graphite. Start the vacuum pump and replace the temporary dust cover.

(8) Remove the cell body from the boiling water and blow dry with inert gas. Inspect the end to be sealed to the window, and remove any foreign material with a clean cotton swab and inert gas.

(9) Remove the dust cover and install the cell body in the vee block. Position the cell body with the fill stems aligned with the window alignment mark so that it is in contact with the sapphire window. The fill stem alignment gauge (fig. 13) is used to insure that the fill stems are in the correct positions relative to the vee block and therefore properly aligned. Clamp the cell to the vee block. Place a loose fitting glass or ceramic cover

over the open end of the cell body. Use the Z axis translator to separate the window from the cell body by a very small amount (approximately 0.005 inch). The assembly fixture at the start of making the first window seal on a HALOE long gas cell is shown in figure 14. Note that a handle has been inserted into a hole in the Z axis control knob to facilitate translation along the Z axis.

(10) Turn on the inert gas to flow through the purge shroud and around the graphite heating element to minimize graphite oxidation at elevated temperatures.

(11) Turn on the induction heater and gradually increase plate current at a rate of 0.04 amperes every 5 minutes until 0.32 amperes of plate current is reached. Watch the graphite block until a medium orange color is produced. (This is approximately 950°C as determined by three individual tests with an optical pyrometer.) At this point, using the axis component of the translator fixture, raise the sapphire window until the end of the cell body has mushroomed slightly. Allow the glass to flow for 10 to 15 seconds; then retract window slightly (to original setup position) to cause glass to create a fillet at contact area. Reduce induction heater plate current to 0.05 amperes and hold for 5 minutes to allow temperature to slowly decrease. Turn off induction heater, vacuum pump, and inert gas, and allow cell body to cool to room temperature in the assembly fixture.

(12) Remove the cell from assembly fixture and inspect seal with magnifying glass.

(13) Turn the cell over and repeat steps 6, 7, 9, 10, 11, and 12.

(14) When the cell seals have both passed inspection, place identifying glass decal numbers on cell body.

(15) Place protective caps over both windows and both fill stems.

(16) Aneal cell in anealing oven at 565°C for 15 minutes and let cool slowly until oven reaches room temperature.

(17) Keep fill stems covered with protective caps secured with Teflon tape to prevent dust and other contaminants from entering the cell.

(18) Optically inspect seals for quality.

(19) Optically test window alignments with the laser for proper refraction and reflection patterns. The laser setup used for the sapphire window refraction, pairing, and aligning described in section 2.2 is used for this purpose. The alignment measurements taken are identical to those taken to verify window alignment. Figure 15 shows a completed long HALOE cell mounted on the Teflon vee block while final window alignment was being verified.

3.3.2 Procedures for Assembling the Short HALOE Cells and the MAPS Cells

It was necessary to modify the procedures given above to accommodate the short HALOE cells and the even shorter MAPS cells. These cells were too short to be clamped into the vee block (step 11 in section 3.3.1), and it was necessary to fabricate a suitable holding fixture. This fixture, shown in figure 13, consisted of a steatite cylinder 1.090 inches in diameter (same as HALOE Long Cell Body Diameter) and approximately 4.0 inches long with an off axis hole bored for the full length of the cylinder. A vacuum line fitting was inserted into this hole on one end of the cylinder. The other end of the cylinder was machined to mate with the steatite cell holders shown in figure 16. The cell holders were fastened to the fixture by graphite dowels because of the high temperatures encountered.

As figure 16 shows, the cell holders were recessed to hold the cell bodies. The diameters of the recesses were machined to give very close fits to the cell body diameters. When the first end seal was being made, the cell body was fit snugly against the end of the recess and held in place with the set

screws shown. When the second end seal was being made, a vacuum was used to pull the sapphire window down onto the machined surfaces and the set screws were used to prevent the cell from falling out in the event of a loss of vacuum. The notches in the cell holders (fig. 16) prevented interference with the fill stems on the short cells.

The MAPS cell bodies, particularly the 2-inch diameter cells, exhibited a strong tendency to crack after cooling. Examination with a polariscope revealed that the slow cooling (step 11 in section 3.3.1) was insufficient to relieve the stresses caused by the differences in coefficients of expansion. This problem was overcome by inserting the annealing process (step 16) immediately after the window sealing process each time a window seal was made.

3.3.3 Post-Assembly Cleaning and Storage

(1) The cell was soaked in NOCHROMIX™ cleaning solution.

(2) The cell was rinsed with five changes of deionized water.

(3) The cell was placed in a vacuum oven and slowly heated to 165°F for 1 hour.

(4) The oven was cooled to room temperature and maintained under vacuum until the time came to transfer the cell to a vacuum desicator. Before opening the vacuum oven, it was backfilled with dry nitrogen to prevent introduction of moisture into the completed cells.

4.0 Concluding Remarks

The Halogen Occultation Experiment (HALOE) and the Measurement of Air Pollution from Satellites (MAPS) experiment both use the gas filter correlation technique to measure atmospheric trace gas concentrations from satellites. The gas filter technique relies on the use of trapped gas samples to act as selective filters in the instrument optical train. The HALOE and MAPS instruments use glass cells made of borosilicate glass tubes with sapphire

windows to hold the gas samples. These cells were fabricated at the Langley Research Center. The fabrication process included the use of documented heating and glassblowing procedures. The HALOE design also imposed significant requirements for window pairing and window alignment relative to the cell axis, and both HALOE and MAPS required cell cleanliness. Procedures were developed which met these requirements while simultaneously providing glass-to-sapphire seals which met the design strength requirements associated with the launch and space vacuum environments. This report details the development of these procedures.

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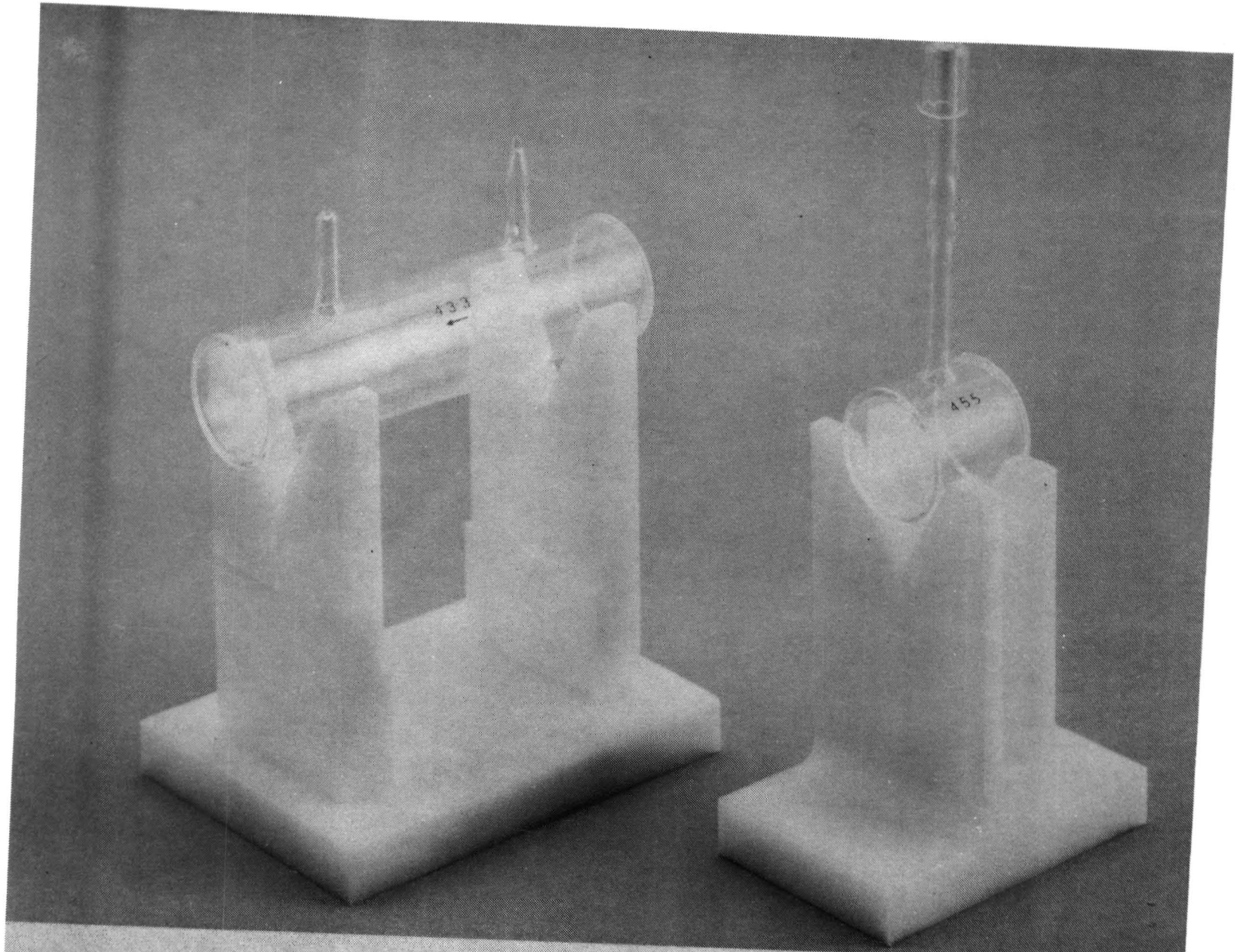


Fig. 1: PHOTOGRAPH OF HALOE CELLS

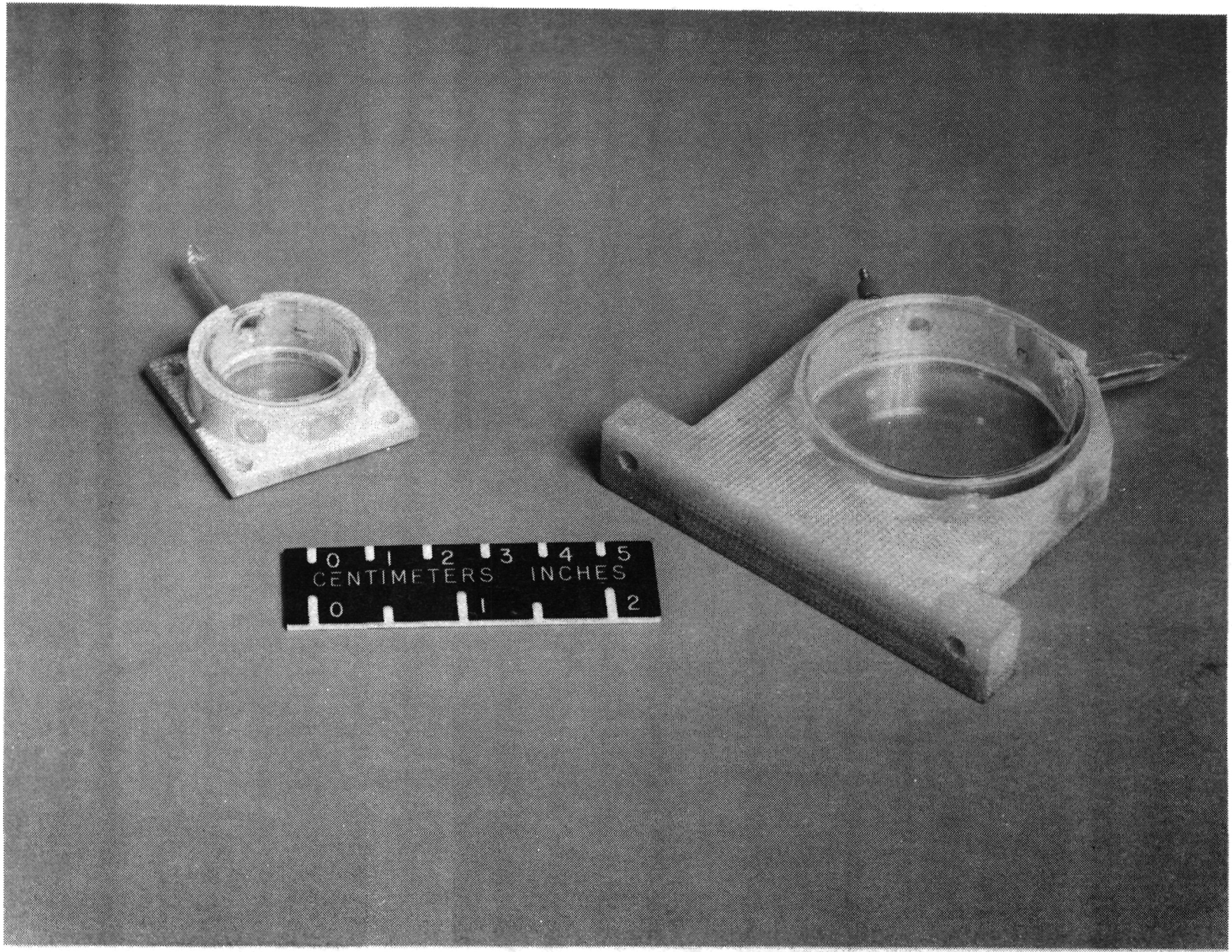
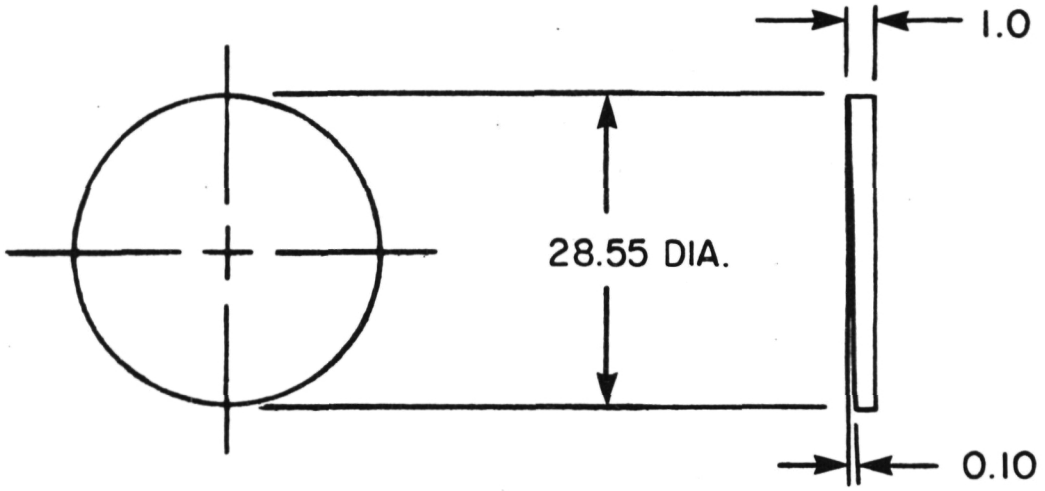
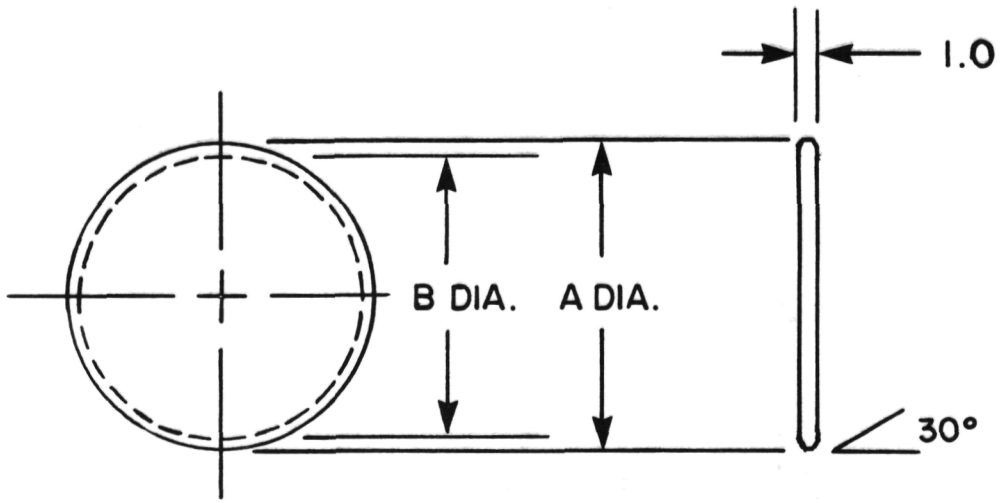


Fig. 2: PHOTOGRAPH OF MAPS CELLS MOUNTED IN THEIR HOLDERS



Dimensions in mm

FIGURE 3: DIMENSIONED SKETCH OF HALOE WINDOWS



	1" CELL	2" CELL
A	28.55	50.80
B	28.27	50.50

Dimensions in mm

FIGURE 4: DIMENSIONED SKETCH OF MAPS WINDOWS

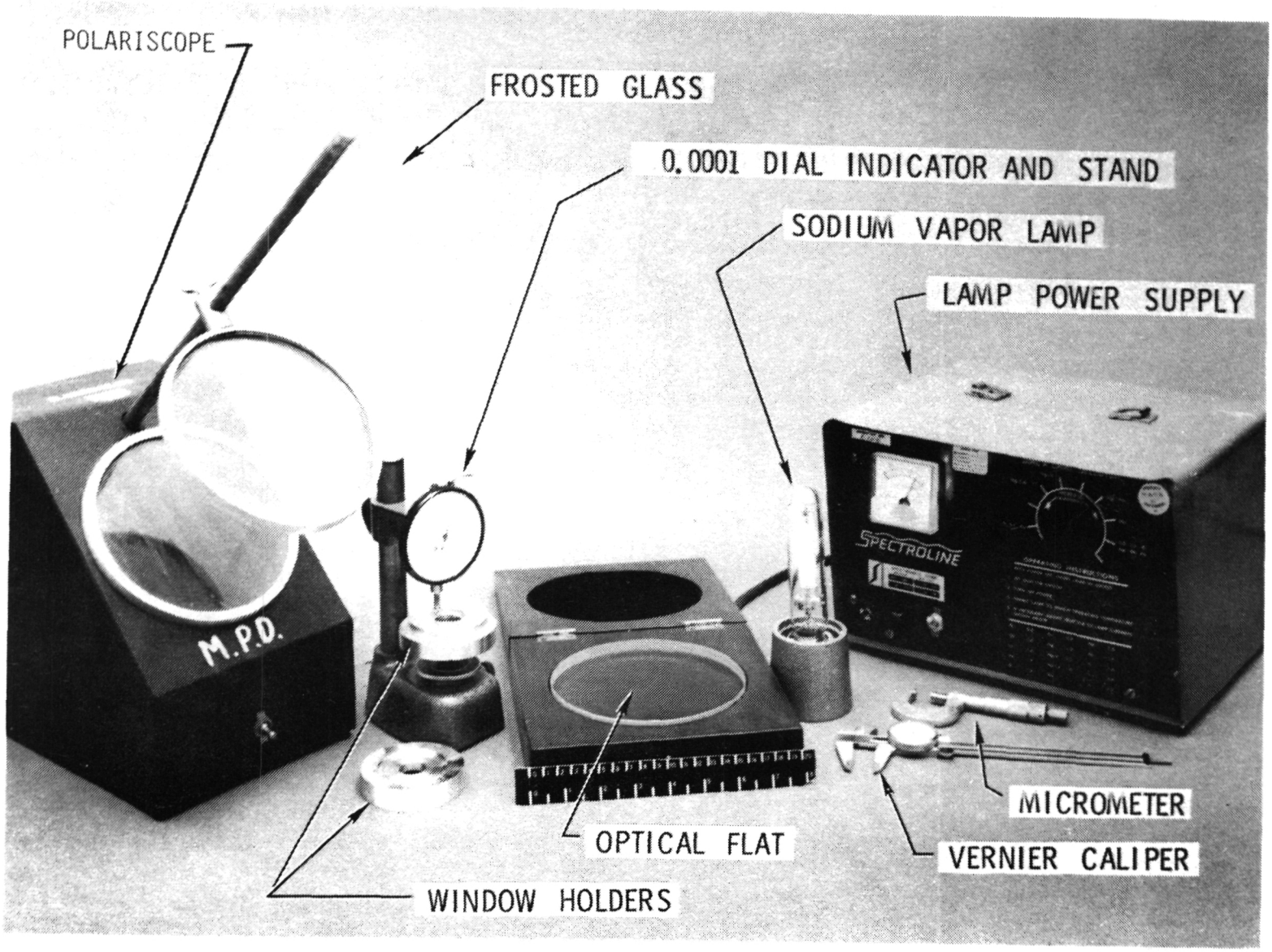


Fig. 5: WINDOW INSPECTION EQUIPMENT

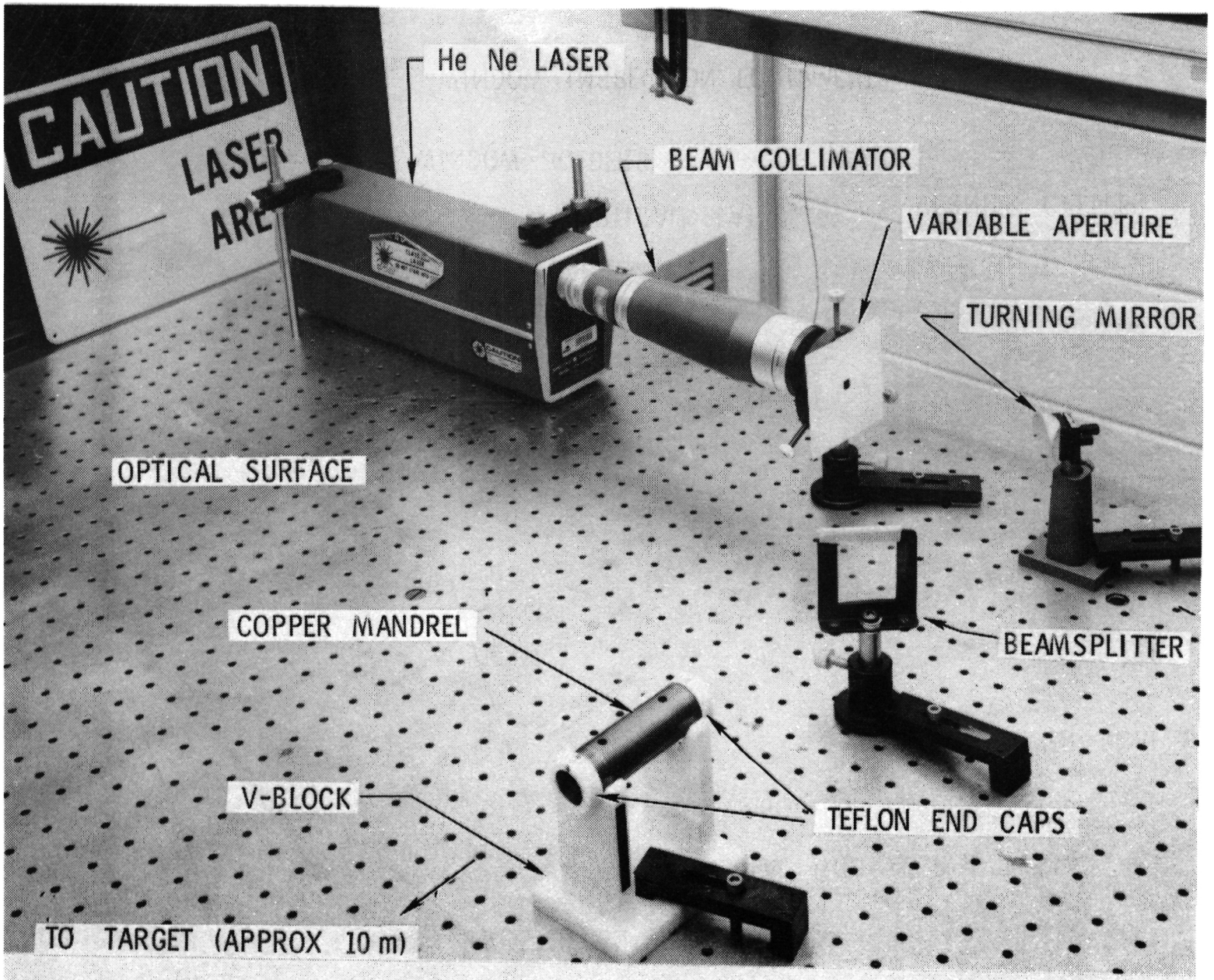


Fig. 6: REFRACTION ANGLE MEASUREMENT AND WINDOW PAIRING EQUIPMENT

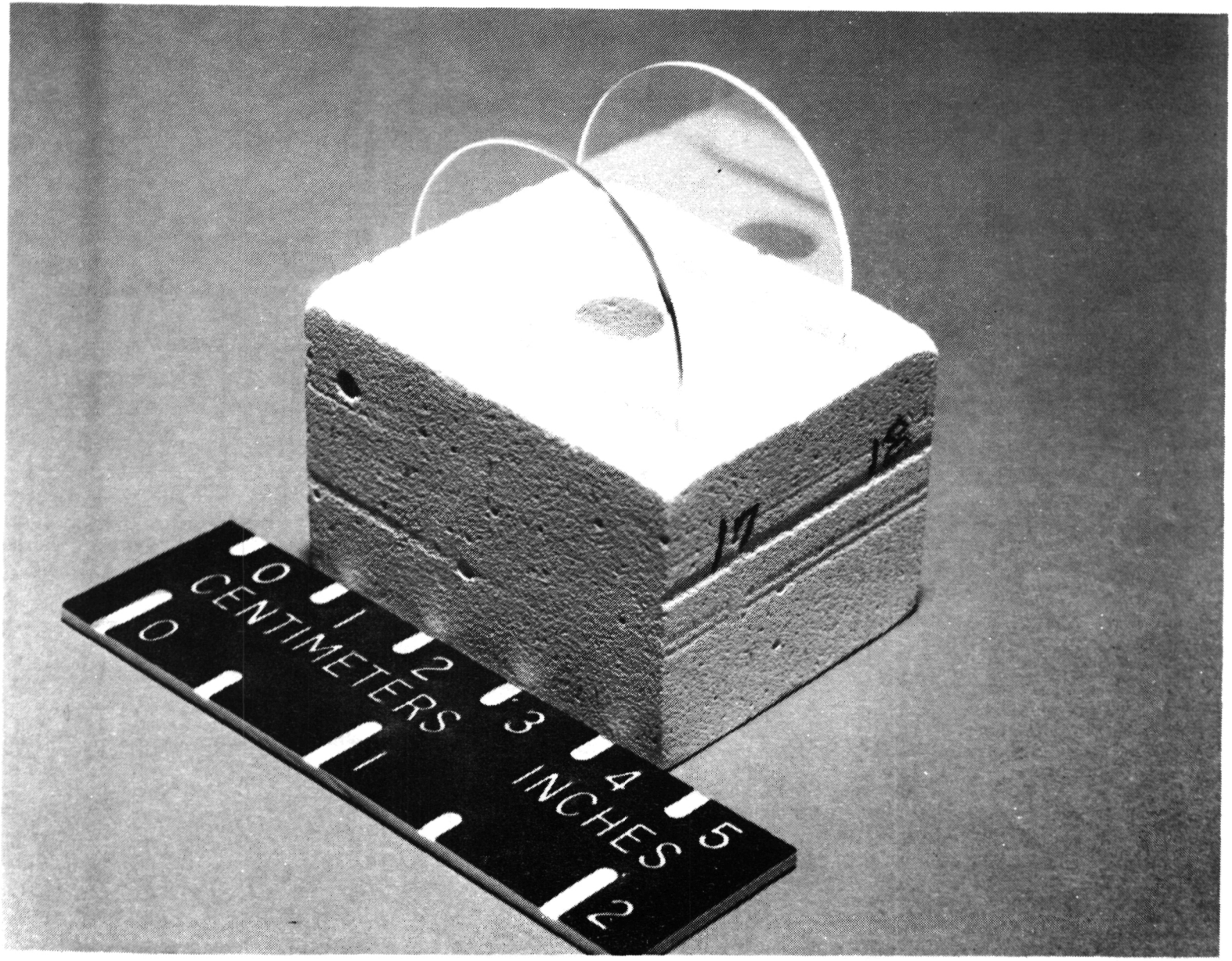


Fig. 7: QUARTZ BLOCK WITH WINDOWS

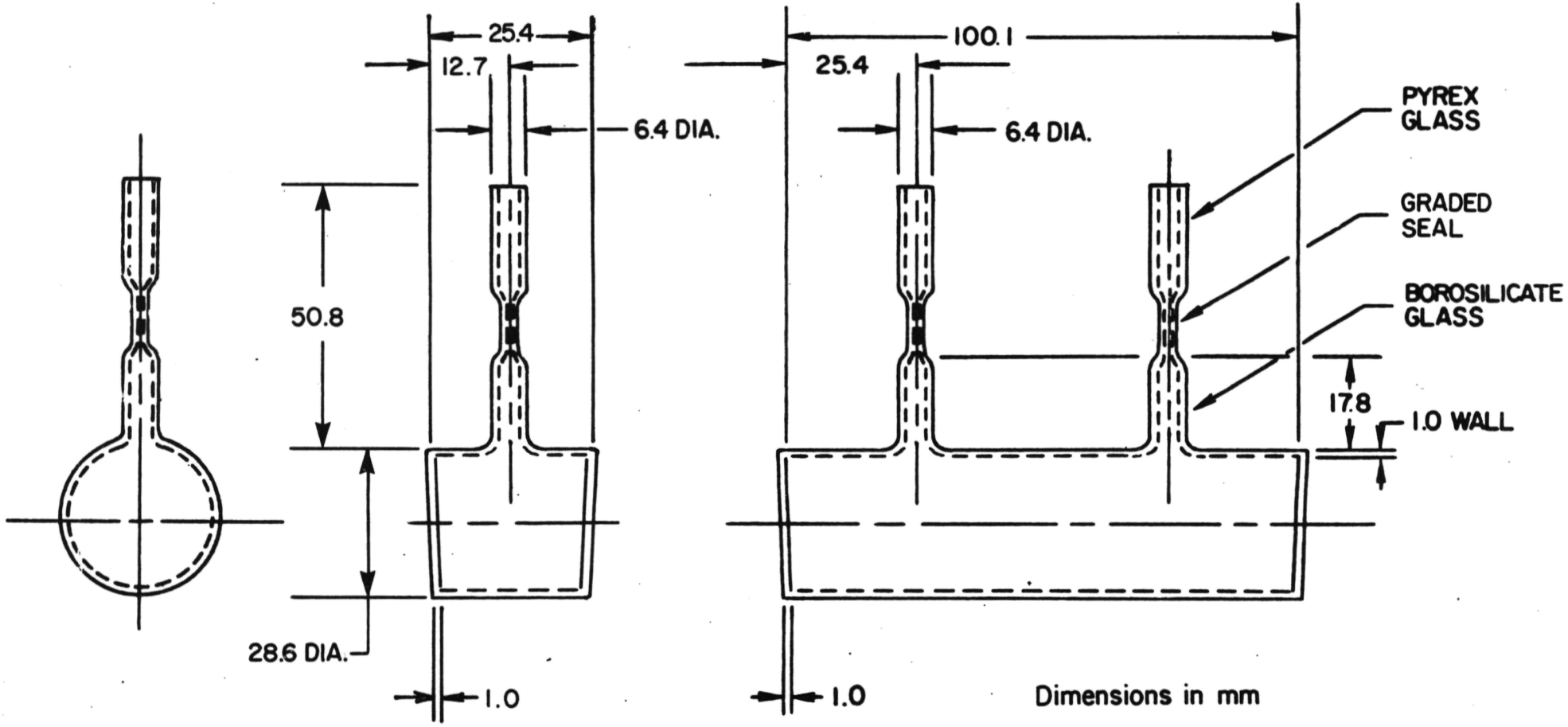
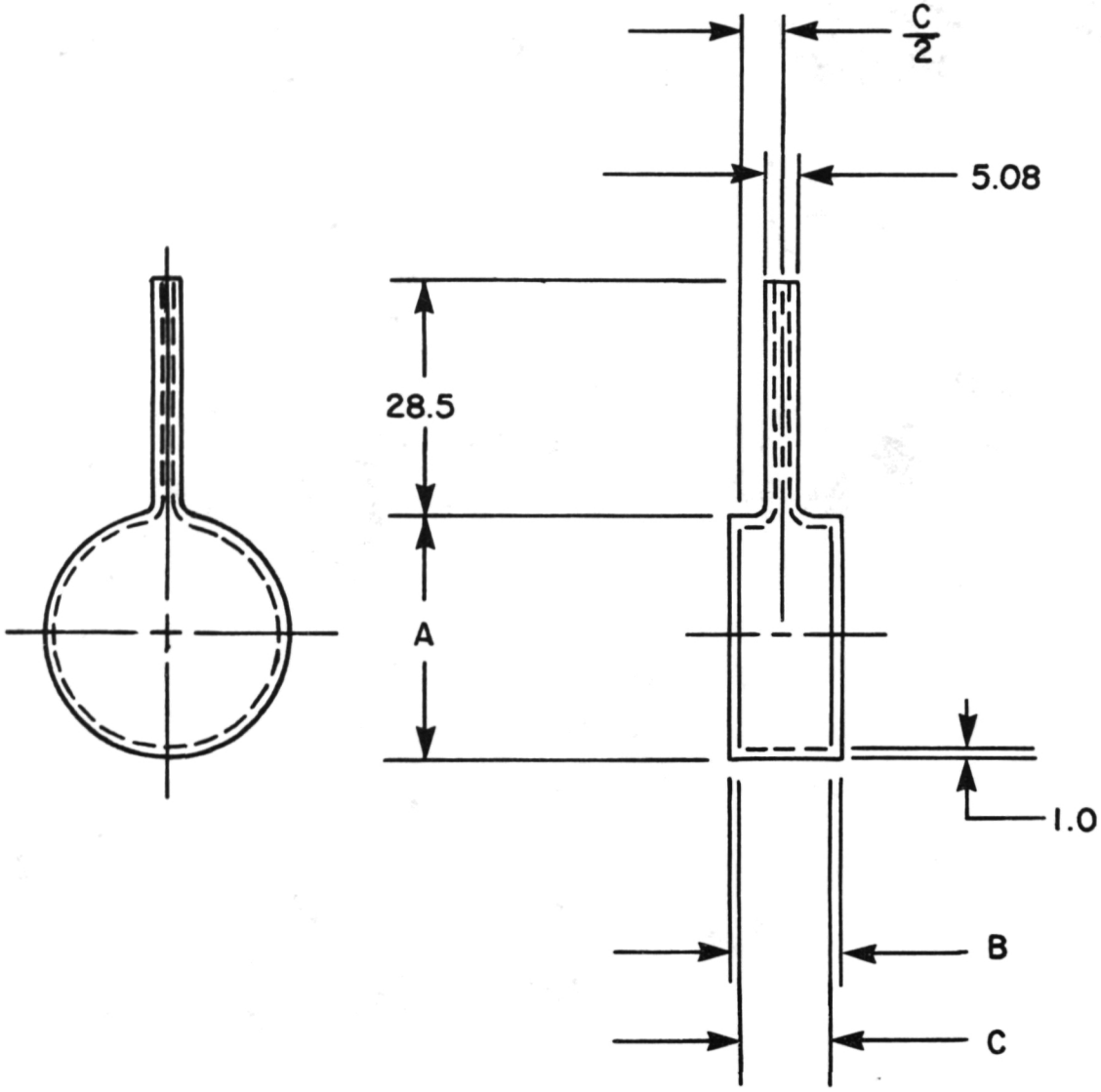


FIGURE 8: DIMENSIONED SKETCHES OF HALOE CELLS



	1" CELL	2" CELL
A	28.58	50.80
B	12.04	16.51
C	9.91	14.48

Dimensions in mm

FIGURE 9: DIMENSIONED SKETCHES OF MAPS CELLS

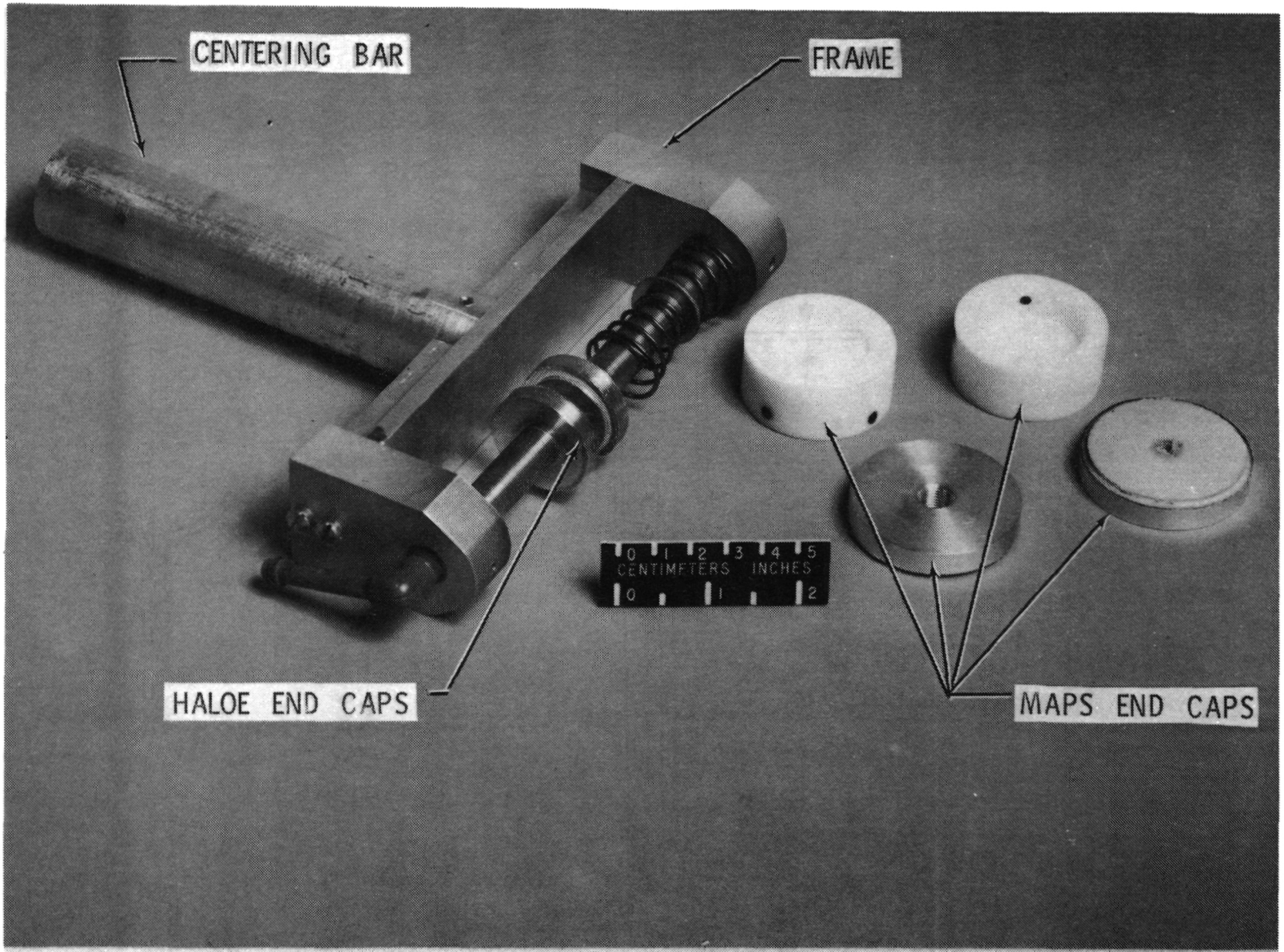


Fig. 10: FILL STEM TO CELL BODY ASSEMBLY FIXTURE

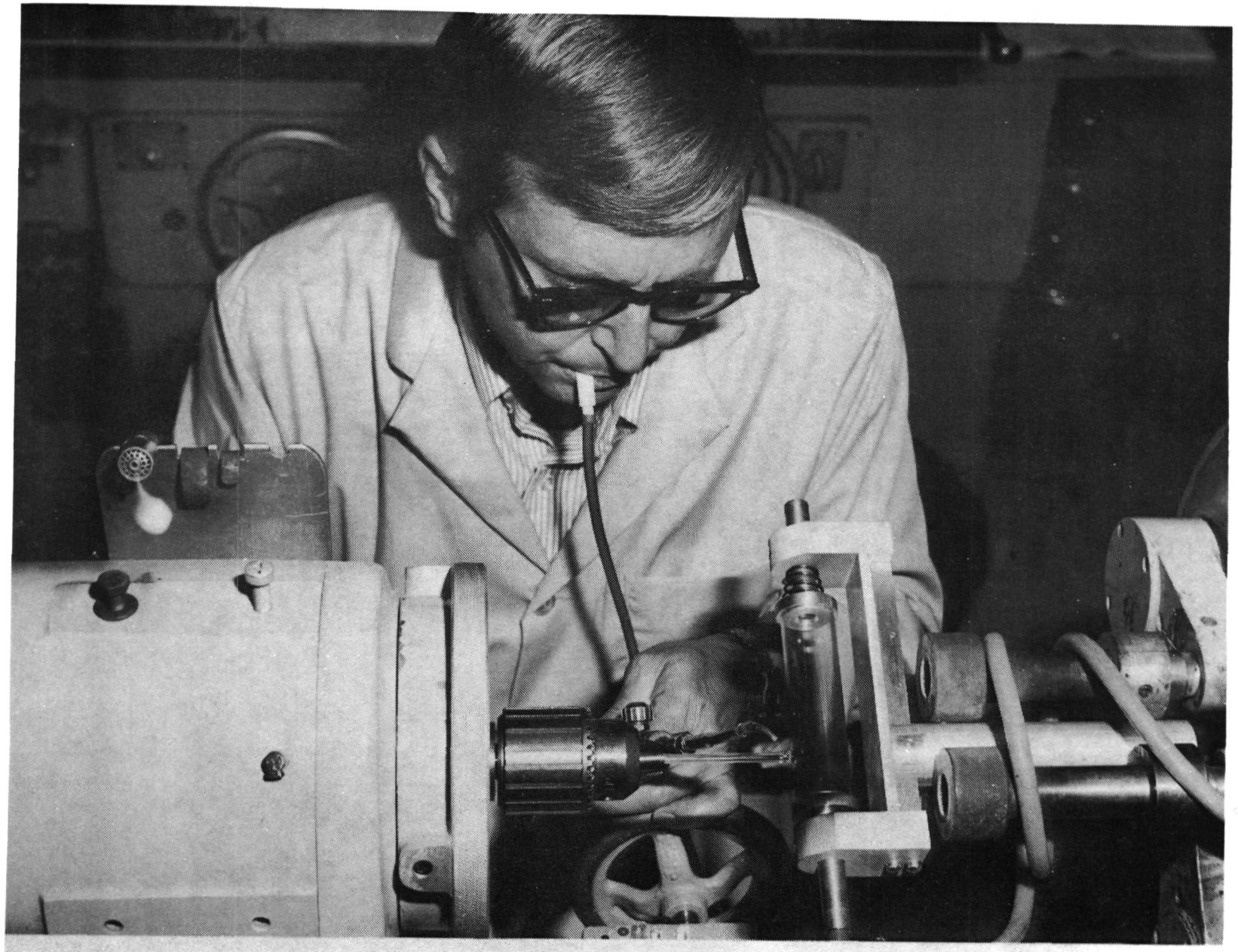


Fig. 11: ASSEMBLING FILL STEM TO LONG HALOE CELL BODY

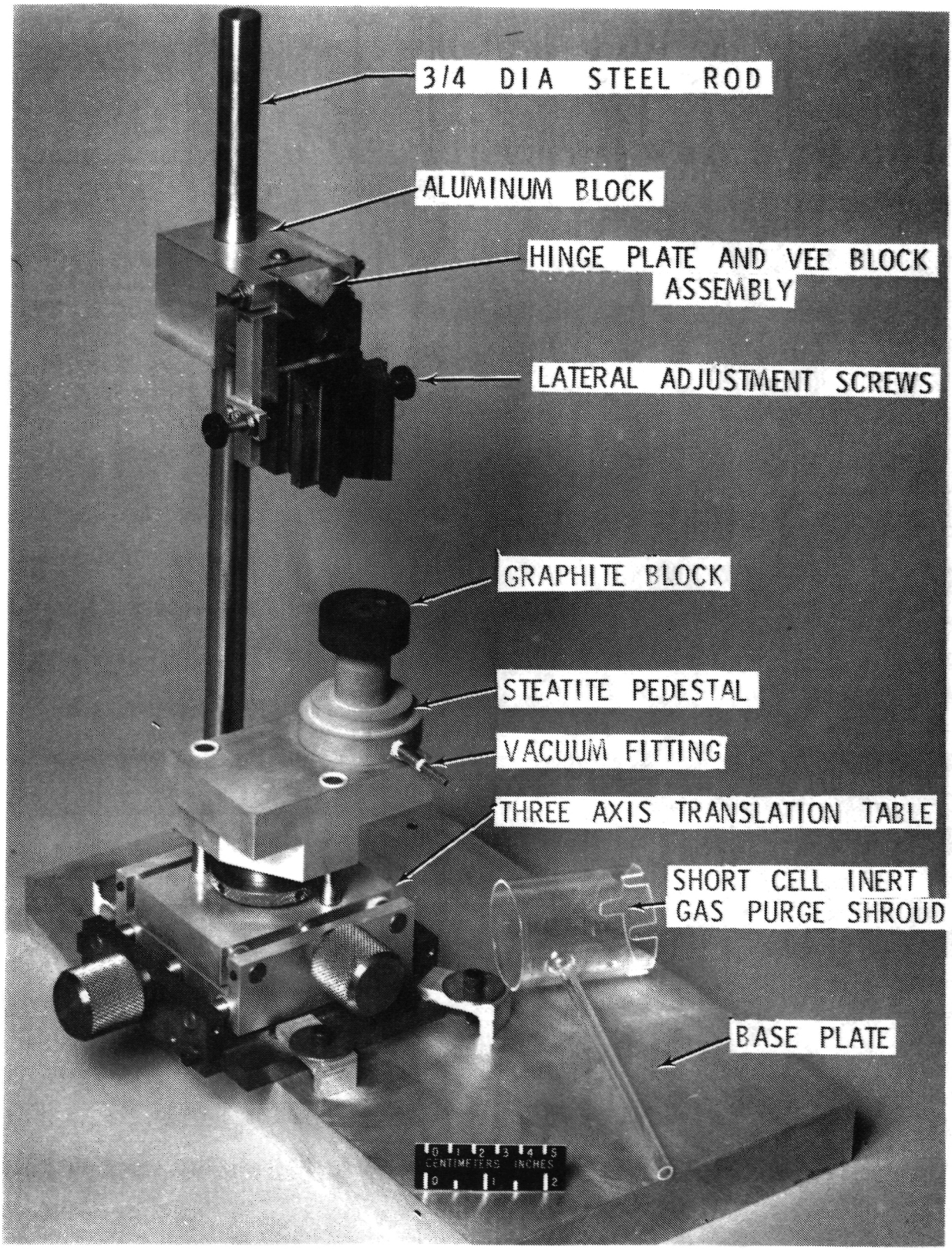


Fig. 12: CELL ASSEMBLY FIXTURE

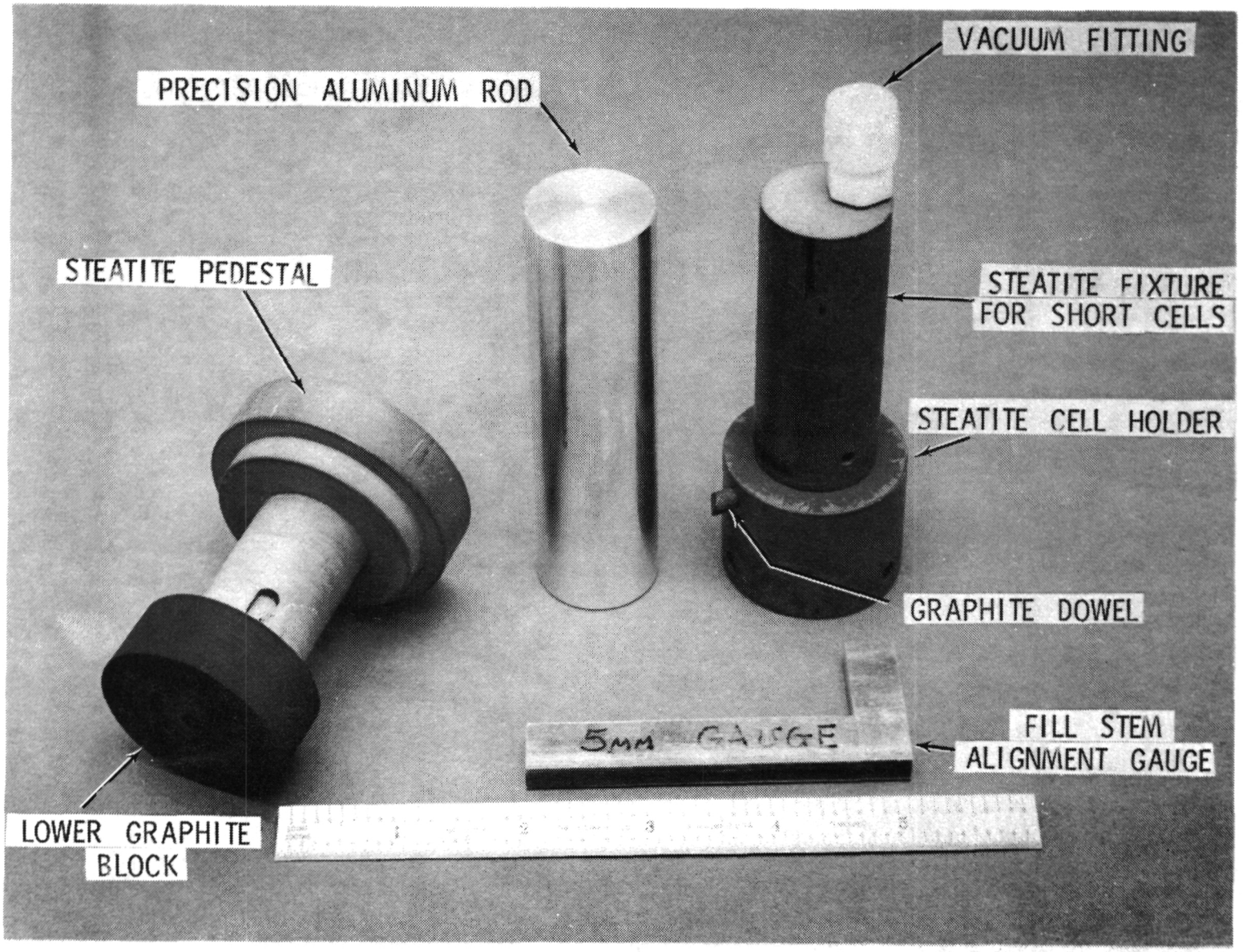


Fig. 13: ALIGNMENT GAUGES AND HOLDING FIXTURES

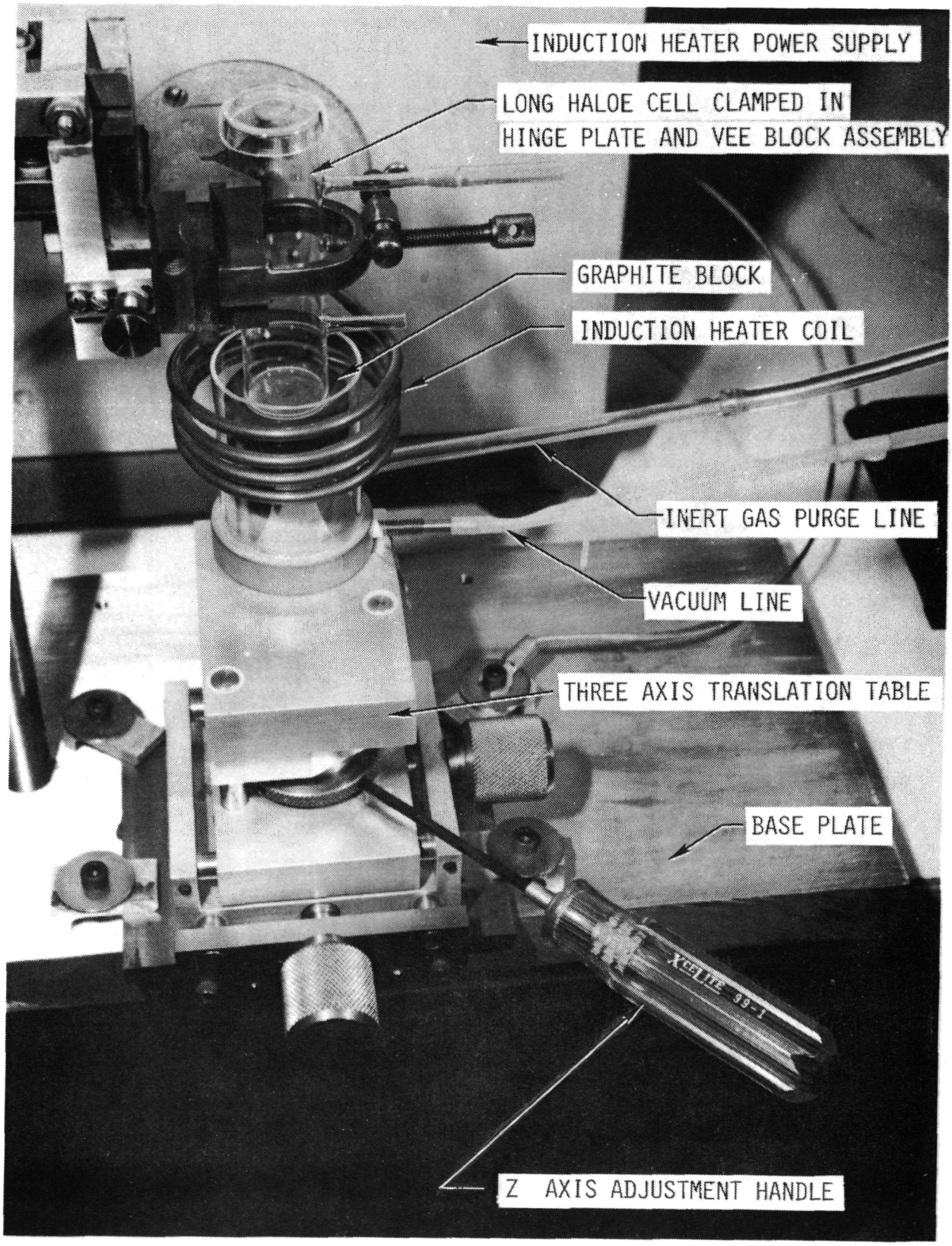


Fig. 14: ASSEMBLY FIXTURE READY FOR SEALING FIRST WINDOW ON A LONG HALOE GAS CELL

Fig. 15: USE OF LASER BEAM TO VERIFY WINDOW ALIGNMENT ON A COMPLETED HALOE CELL

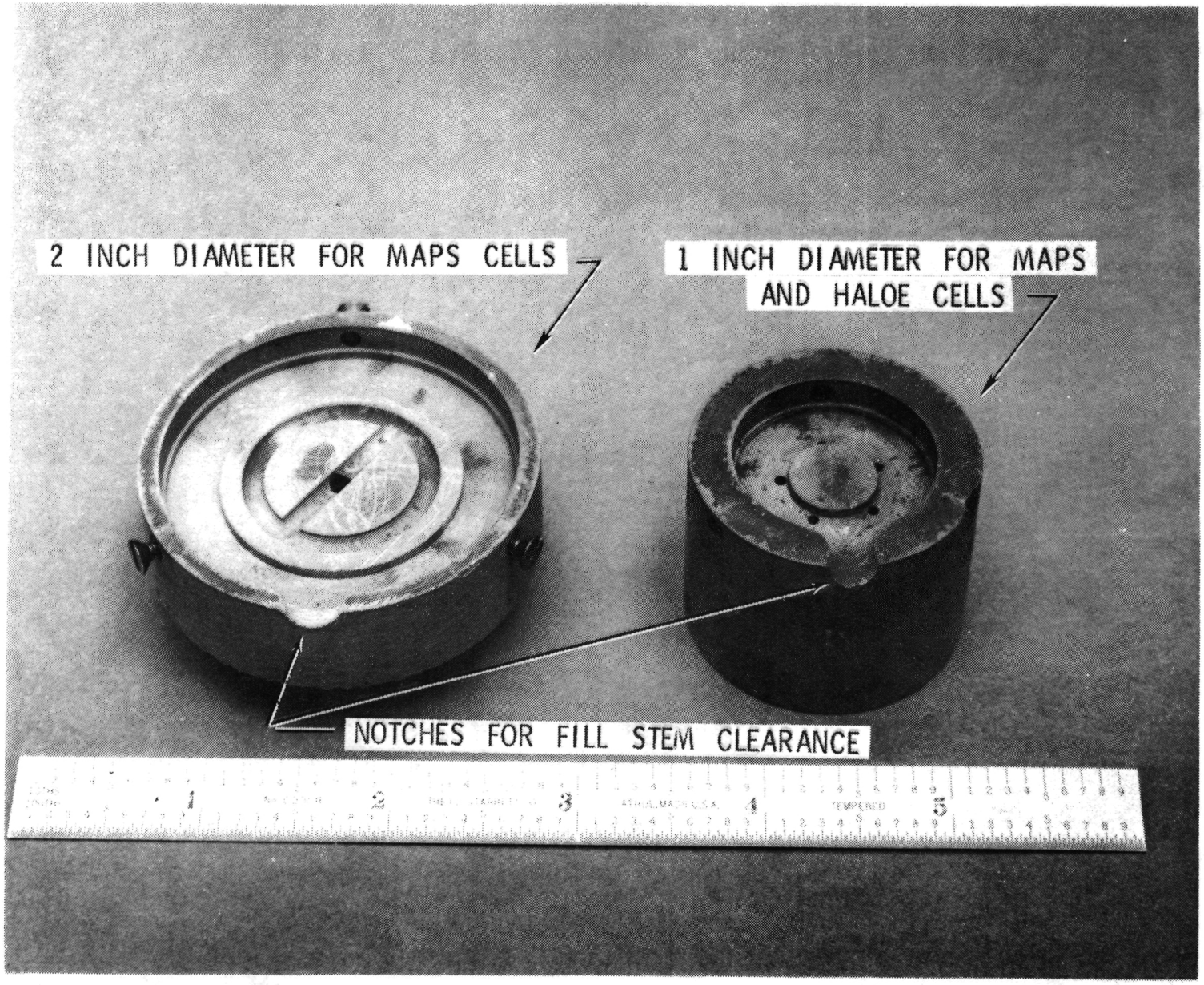


Fig. 16: STEATITE CELL HOLDERS FOR SHORT CELLS

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15. Supplementary Notes

16. Abstract

The Halogen Occultation Experiment (HALOE) and the Measurement of Air Pollution from Satellites (MAPS) experiment are satellite-borne experiments which measure trace constituents in the Earth's atmosphere. The instruments which obtain the data for these experiments are based on the gas filter correlation radiometer measurement technique. In this technique, small samples of the gases of interest are encapsulated in glass cylinders, called gas cells, which act as very selective optical filters. This report describes the techniques employed in the fabrication of the gas cells for the HALOE and MAPS instruments. Details of the method used to fuse the sapphire windows (required for IR transmission) to the glass cell bodies are presented along with detailed descriptions of the jigs and fixtures used during the assembly process. The techniques and equipment used for window inspection and for pairing the HALOE windows are discussed. Cell body materials and the steps involved in preparing the cell bodies for the glass-to-sapphire fusion process are given.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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